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Chip Scale Interferometry – A micro fluidic platform for biochemical sensing

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When illuminating a micro fluidic channel with a coherent laser, a highly modulated fringe pattern occurs perpendicular to the channel. The bright and dark spots shift their angular position when changing the refractive index of the sampled liquid inside the channel. Monitoring this shift is the basis of this sensor. Performed in fused silica capillary tubes has been able to detect changes in the refractive index at 10-8 level. Here is presented modelling and platform development of this sensor. The optical train of the capillary tube has been investigated by a ray-tracing model, which has shown good correlation with the experimental data, including the possibility to perform absolute measurement of the refractive index with high accuracy. An analytical solution to Maxwell's equations has also been developed to further describe the capillary system, including protein-binding studies on the glass surface. This analytical model has shown to describe the directly backscat
tered fringe pattern with higher accuracy. The interferometric sensor has been under constant development in the last 10 years. One major step is to change from capillary tubes and into the micro fluidic network scenario.
Normal photolithography processes and following casting of the microstructures usually results in rectangular shaped micro flow system. Those flow chips have been fabricated in elastomer material (PDMS) and has shown good experimental results on biochemical sensing, such as DNA-hybridization and protein-protein interaction. The reproducibility of these measurements depends critically on the flow channel dimensions. Hence, improvements in performance and system integration are predicted by transferring the well-defined capillary geometry to a polymer chip-based system with a high degree of accuracy and reproducibility. A final goal is to perform chip scale interferometry (CSI) with as high sensitivity as capillaries and all the advantages of micro fluidic advances including mixing of samples. Our channel systems are based on isotropic etching through narrow entry lines defined by photolithographic procedures. Photolithography has traditionally been employed for the generation
of rectangular or triangular shaped channels. However, in this study we demonstrate its unconventional combination with isotropic wet etching in fused quartz and in silicon to form well-defined semicircular channels of cross-sectional dimensions of 100µm. A number of optimizations of the etching mask have been performed for achieving a satisfactory geometry of the flow system. For the etching in fused quartz a metal mask has been used comprising a thin Cr layer for adhesion and a thick layer of Au for mechanical stability, using buffered HF as etchant. Etch channels in silicon were defined by a patterned Si3N4 layer, using a mixture of HF, nitric acid, and acetic acid as etchant. The etched channels have been characterized by microscopy performed on PDMS replicas and by 3D profilometric measurements. The structure, a half circle, is electroplated into a nickel replica that is subsequently used as mold for injection molding. Multiple thermoplastic flow chips have been fabricated and assembled for chip scale interferometry. The CSI-sensor has shown detection limits of Dn = 1×10-5, well in the range of monitoring biological relevant samples.